

N 93 - 22083

2.2 National Launch System Structures and Materials - Jack O. Bunting, Martin Marietta Astronautics Group

Dr. Bunting stressed that Al-Li should be incorporated as a major structural material in space transportation vehicles. The National Launch System, as a joint NASA / Air Force program, provides an opportunity to realize the potential of Al-Li. Advanced structures can reduce weights by 5-40% as well as relax propulsion system performance specifications and reduce requirements for labor and materials. The effect on costs will be substantial. For example, a redesigned external tank fabricated from Al-Li would weigh 8 klb less than existing ET's and, as a result, reduce effective launch costs by \$800 per pound of payload.

Advanced assembly and process control technologies also offer the potential for greatly reduced labor during the manufacturing and inspection processes. Current practices are very labor-intensive and, as a result, labor costs far outweigh material costs for operational space transportation systems.

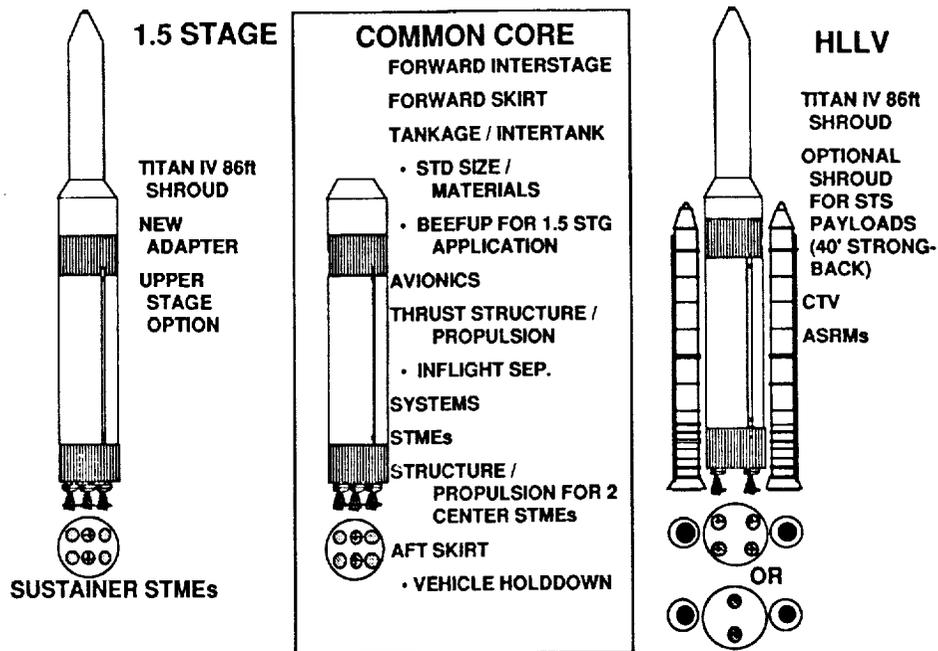
The technological readiness of new structural materials depends on their commercial availability, producibility and materials properties. Martin Marietta is vigorously pursuing the development of its Weldalite™ 049 Al-Li alloys in each of these areas. Al-Li alloys are now commercially available, they have been used in high quality welds, and they perform as expected in terms of yield strength and ultimate strength. Martin Marietta tests have demonstrated satisfactory welds using a variety of techniques in test articles composed entirely of Al-Li and in joining Al-Li to aluminum. Preliminary demonstrations of producibility based on the design of the Space Shuttle external tank have also been successful, and more complex tests are continuing.

Martin Marietta is also preparing to test an automated work cell concept that it has developed using discrete event simulation. One of the goals of this effort is to develop a manufacturing process that features continuous inspection of welded joints as they are created and thereby eliminate the time consuming practice of inspecting welds after the fact as a separate step of the fabrication process. Martin Marietta is currently procuring tooling for initial demonstrations.

NLS Structures and Materials

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Baseline Vehicles



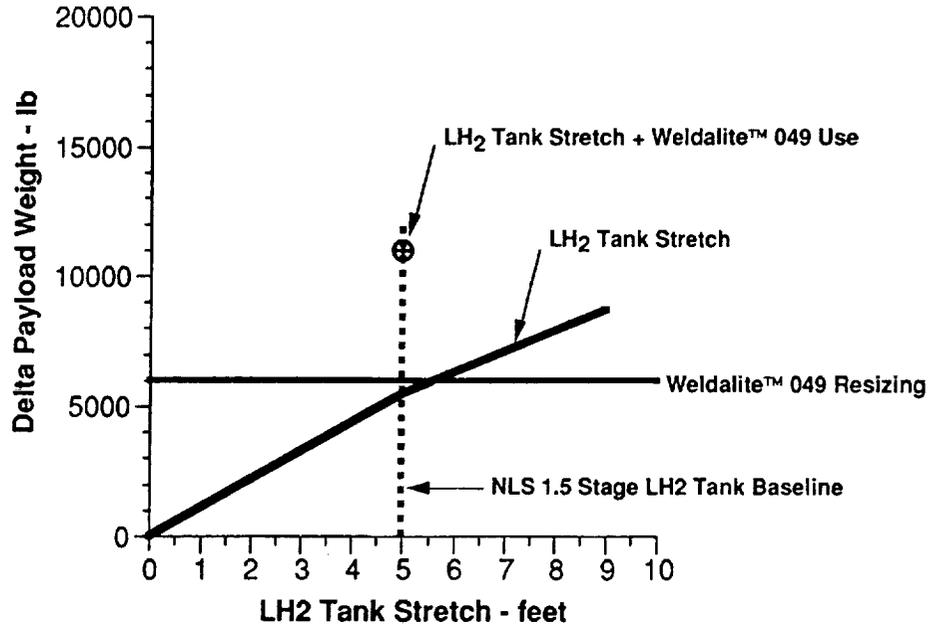
Existing Launch Vehicles

Structures Technology	Assembly & Process Control Technology
- Aluminum Alloys 2219,2014	- Manual Material Handling
- Fabrication Techniques	- Manual Part Set-Up
- Machine, Stretch Form	- Manual Part Weld Prep
- Chem Mill to Tight Tolerances	- Manual Part Fit-Up
- Manual Inspection	- Point Design Weld Processes
	- Manual Inspection

Advanced Technology

Structures Technology	Assembly & Process Control Technology
- Reduce Weight (5 - 40%)	- Reduce Direct Assembly Labor (30%)
- Reduce Direct Labor/Material	- Reduce Major Weld Labor (34%)
- Reduce Support Labor	- Reduce Inspection Labor (33%)
- Reduce Propulsion Requirements	

Delta Payload vs Stretch for Weldalite™ 049 Substitution



Weldalite™ 049 and The External Tank (ET)

- Redesign of the ET Using Weldalite™ 049 Can Result in A Weight Savings of Approximately 8000 lb
- This Equates to a Savings of Cost to Orbit of about \$800/lb

Al-Li Alloys

Success Criteria

- **Demonstrated Production Capability**
- **Demonstrated Cost Advantage through Higher Strength**
- **Adequate Fracture Toughness**
- **Adequate Stress Corrosion Resistance**
- **Demonstrated Manufacturability**

Technology Readiness of Al-Li Alloys

<u>Requirement</u>	<u>Present Status</u>
• Commercial Availability	Alloys Are Currently Available
• Producibility	
- Forming	Full Scale External Tank Gores and Extruded Chords Have Been Produced. All Meet Design Tolerances
- Chem-milling	Chem-milled Gores Meet Design Requirements
- Machining	Extruded Chords Have Been Machined and Meet Design Requirements

Technology Readiness of Al-Li Alloys (Concl.)

<u>Requirement</u>	<u>Present Status</u>
Welding	High Quality Welds Have Been Produced by All Conventional Processes Including VPPA. Backside Shielding Concepts Have Been Demonstrated
Design Allowables	All Product Forms of Weldalite™ 049 Have Been Shown to Meet the Specified Yield Strength of 85 ksi and the 90 ksi Ultimate Strength Goal. Reynolds Will Begin the "S" Basis Allowables Program in Late 1991

Advanced Cryotank Program - ADP 3106 Wedalite™ 049 Development

1988

- Concurrent Engineering Team Formed
 - Martin Marietta
 - Reynolds Metals Co.
 - Universities
 - Government Agencies
- Laboratory Production at RMC
- Lab Scale Properties Exceed Other Tankage Alloys

Material	320°F (MPa)	75°F (MPa)
Wedalite™ 049-T6	~750	~650
2090-T81	~500	~450
2219-T87	~450	~400

1989

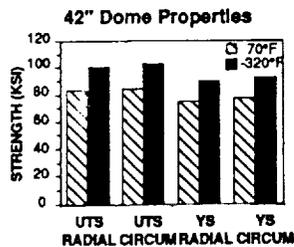
- Full Scale Production at RMC
 - 13,000 lb Ingots Produced
 - Plate and Sheet Material Characterized
 - Typical Properties
 - F_{tu} = 100 ksi
 - F_{ty} = 90 ksi
- Small Scale Net Shaped Products Manufactured
 - Hook Forgings
 - Domes (18" Dia)
 - Extrusions
- Weldability Demonstrated

Material	-500°F (ksi)	-400°F (ksi)	-300°F (ksi)	-200°F (ksi)	-100°F (ksi)	0°F (ksi)	100°F (ksi)
SIGTA	~65	~60	~55	~50	~45	~40	~35
DTGTA-VP	~60	~55	~50	~45	~40	~35	~30
VPPA	~55	~50	~45	~40	~35	~30	~25
VPPA (2219)	~45	~40	~35	~30	~25	~20	~15

Advanced Cryotank Program - ADP 3106 Weldalite™ 049 Development

1990

- Large Products Produced
 - Extruded External Tank (ET) Chord
 - ET Gore Panels
 - Domes (42" Dia)
 - Extruded Barrel Panels (18" Width)
 - Roll Forged Ring (34" Dia)



1991

- In Progress:**
- Integrally Stiffened Extruded Tube Producing 105" Wide x 360" Length Barrel Panel
 - 120" Dia Dome Spin Forming
 - Weld Process Optimization

STATUS:

- Alloy - Lab to Production in 3 Years
- Net Shapes Demonstrated
- Exceeded Mechanical Property Goals

1992-93

- Components for 14' Dia Tank Manufactured
- Fabricate Tank
- Test Tank at Cryogenic Temperatures

